




Available online at
 ScienceDirect
www.sciencedirect.com

Elsevier Masson France

www.em-consulte.com



ORIGINAL ARTICLE

Intraoperative fractures and ligament tears during total knee arthroplasty. A 1795 posterostabilized TKA continuous series

A. Pinaroli^a, S.R. Piedade^b, E. Servien^a, P. Neyret^{a,*}

^a Knee Surgery Department, Livet Hospital, Albert-Trillat Center, 8, rue de Margnolles, 69300 Caluire, France

^b Department of Orthopaedics and Traumatology, School of Medical Sciences, State University of Campinas, Sao Paulo, Brazil

Accepted: 25 April 2008

KEYWORDS

Total knee arthroplasty;
 Intraoperative complications;
 Periprosthetic fracture;
 Ligament injuries

Summary

Introduction. – Intraoperative fractures are a reported complication during the course of primary total knee replacement. Major ligament disruptions can also occur. Clinical data are lacking to tell how much these incidents affect implantation quality and outcome.

Hypothesis. – A thorough knowledge of these occasional incidents helps proper decision making when confronted to such situations at surgery.

Materials and methods. – This report is based on a series of primary, posterostabilized total knee arthroplasties (posterostabilized, mobile bearing TKA with a third median condyle from Tornier Laboratory). We studied all possible mechanical complications that developed during the course of arthroplasty and analyzed their cause. We compared the functional results of patients presenting these complications to those of the total series and to data from the literature. The entire operative reports for the 1795 TKA performed during this study were available and evaluated. A clinical and radiological review was performed for 1624 patients at an average follow-up time of 36.8 ± 34 (2–193) months.

Results. – At this last follow-up, the average International Knee Society (IKS) score was 91.2 (19–100) and the function score was 77.76 (0–100). One hundred and thirty-two patients were deceased (unrelated to TKA) at this last follow-up evaluation. A total of 69 mechanical complications were accounted for at the time of surgery (3.8%): 40 definite fractures or fissures around the knee (2.2%), 29 tendon or ligament disruptions or attenuations (1.6%). The risk of tibial cracks was statistically more significant, with the smaller sizes tibial trays (size 1) ($p=0.019$) or when an anterior tibial tuberosity elevation had been performed ($p=0.02$). Survival curve analysis (at an average seven and a half-years postoperative follow-up) showed that all prosthetic components were still present in 93.3% of cases in the series of patients with these peroperative complications, and in 93.8% of cases in the series of patients without

* Corresponding author.

E-mail address: philippe.neyret@chu-lyon.fr (P. Neyret).

these intraoperative complications; this survival rate amounted to 91.9% of cases at an average 16-years postoperative follow-up.

Conclusion. — This large, homogeneous series of primary, posterostabilized TKA took on 3.8% of intraoperative bone or ligament complications. All these complications could be prevented by a rigorous surgical technique. The improvement of ancillary materials, the saws, and good knowledge of such complications by the surgeon are essential.

Level of evidence: Level IV. Therapeutic Study.

© 2009 Elsevier Masson SAS. All rights reserved.

Introduction

Total knee arthroplasty (TKA) is now a reliable and reproducible procedure, thanks mostly to improvements of ancillary materials supplied by the manufacturers. Analysis of the procedure's success is very subjective, and many scales allow its evaluation. Failure of TKA is always difficult to define.

Changing one piece or all prosthetic components clearly represents surgical failure from varied causes. Two large categories may thus be identified: infections, on the one hand [1], and mechanical failures, on the other hand.

In the latter category, failure may be attributed to the surgeon (implant malpositioning or technical error may lead to femorotibial instability, for example) [2] or to the implants themselves (polyethylene wear [3,4], implant rupture, metallosis). However, other complications are difficult to impute to a particular cause: aseptic loosening may be due to poor cementation (by the surgeon), helped by the release of polyethylene particles (from the implant), or by some major activity and excess weight (patient).

These failures may be evaluated objectively by calculating implant survival curves.

Complications ensuing during surgery may also modify the postoperative outcome and affect the functional prognosis of TKA. The procedure itself may also be seen as a failure by the patient.

Intraoperative complications are due to surgical technique and may be manifold: periprosthetic, intraoperative fracture [5], intraoperative tendon or ligament weakness [6–8], nerve [9–11] or vascular [12] complications.

In a series of primary, posterostabilized TKA (gliding, posterostabilized TKA with a third median condyle from Tornier Laboratory, St-Ismier, France), we studied all fractures and ligament tears occurring during surgery and analyzed their cause. We compared the functional results of patients who had these complications to those of patients without such complications and to data from the literature. Defective implant positioning in the frontal plane was not studied in that series and the frequency of anterior femoral notching,

and one year, then every two years after surgery. The intraoperative and follow-up clinical and radiological data were noted in a logbook and fed into a database. The surgery report was included, and the occurrence of different intraoperative complications was also noted.

The clinical examination and interview data were recorded via questionnaire according to the International Knee Society (IKS) criteria, allowing score calculation during each follow-up visit. Radiographic evaluation comprised AP and lateral pictures of the operated knee in monopodal stance as well as patellofemoral incidence at 45° flexion, during each follow-up visit. Pangenometry completed the findings during each follow-up visit, at two months and one year postoperatively, then every two years.

During the period 1987 to 2007, 1795 primary TKAs were performed in 968 right knees and 827 left knees.

The average age during the intervention was 71 ± 8 (20–95) years. The gender ratio was 0.38, in favour of women.

The operated knees had not undergone any previous surgical procedure in three quarter of cases (Table 1).

The main indication for TKA was medial femorotibial arthrosis (Table 2).

Before 1996, a medial approach was the rule for TKA. After that period, the choice of approach was dictated by initial deformation in the frontal plane: the medial approach in cases of genu varum, and the lateral approach in cases of genu valgum (Table 3). When anterior tibial tuberosity (ATT) elevation was necessary, the usual fixation technique employed was fixation by two cortical screws 4.5 mm in diameter.

Since 1987, the prostheses implanted are supplied by the same manufacturer (Tornier Laboratory). The prosthetic design of this tricompartmental, posterostabilized TKA always includes a third median condyle.

The patellas were resurfaced in most cases (eight non-resurfaced patellas=0.4%). All implants were cemented except for 127 femoral implants covered by hydroxyapatite (7%) without cement during the period of a prospective study which will be reported shortly.

Materials and methods

Since November 1987, all patients operated by or under the responsibility of one of the authors (PN), in our university hospital service, for TKA were followed up clinically and radiologically. Thanks to a register created prospectively since 1995 and retrospectively for the earlier period, they were systematically reviewed at two months, six months,

Table 1 Previous surgeries on operated knees.

Previous interventions	Number	%
None	1376	77
1	311	17
More than 1	108	6

Table 2 Reasons for TKA.

		Number	%
Arthrosis	Medial femoro-tibial	1219	68
	Lateral femoro-tibial	256	14.3
	Patellofemoral	61	3.4
	Global	25	1.4
Inflammatory rheumatism		128	7.1
Condyle necrosis		61	3.4
Rare causes ^a		45	2.4

^a Chondrocalcinosis, tibial plateau necrosis, Paget's disease, Klippel-Trenaunay disease, infectious arthritis sequelae, TKA revision, bone tumour.

Table 3 Approaches to TKA.

Approaches		Number	%
Medial	Without ATT elevation	1488	83
	With ATT elevation	19	1
Lateral	Without ATT elevation	170	9
	With ATT elevation	118	7

Among the 1795 TKA implanted during the study period, we consulted all surgical reports. One thousand six hundred and twenty-four TKA were reviewed clinically and radiologically, with an average follow-up of 36.8 ± 34 (2–193) months.

At last follow-up, for the entire series, the IKS score was 91.2 (19–100) and the function score was 77.8 (0–100). For the series of patients without intraoperative complications, the IKS score was 91.2 (19–100) and the function score was 77.7 (0–100).

At last follow-up, 132 patients were deceased (unrelated to TKA).

The statistical data were analyzed by Student's and χ^2 tests, with the Minitab® Statistical Software Package (Minitab Ltd. Unit E1, Brandon Court, State College, PA, USA). Differences in the results were considered significant at $p < 0.05$.

Results

Sixty-nine fractures and ligament tears occurred during the surgery (3.8%): 40 fractures or cracks around the knee (2.2%), 28 tendon or ligament tears (1.6%).

Fractures or fissures

Tibial cracks ($n = 27$)

Fissures of the tibial plateau (27 cases) occurred during preparation of the tibial keel or during impaction of the tibial plateau (Fig. 1).

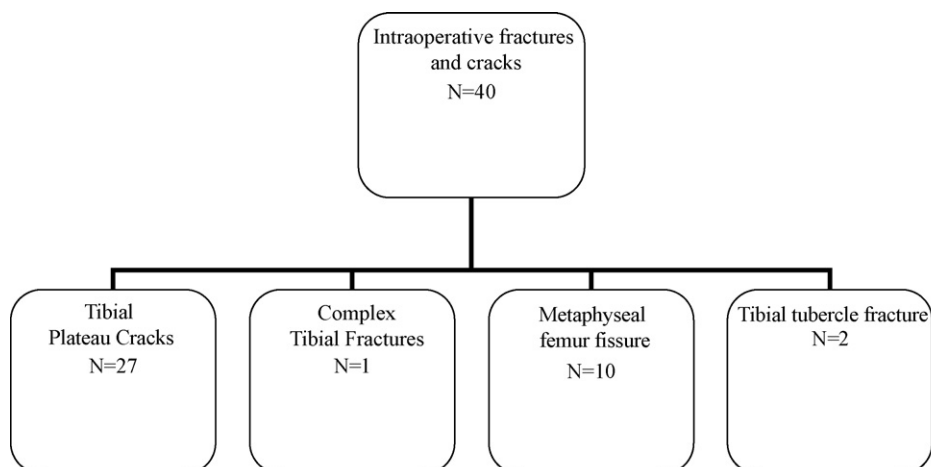
They were treated by the use of a long tibial keel and a minima fixation with 8-shaped metallic wire supported by two screws of 4.5 mm diameter on each side of the keel (Fig. 2).

Stability of the fixation and cimentation of components required immediate support.

The ATT was elevated in 137 cases from the entire series, 11 cracks of the tibial plateau and a complex tibial fracture occurred (8.9%). Thus, the risk of tibial cracks was statistically more significant with ATT elevation ($p = 0.02$).

When a size 1 tibial plate was inserted, there was a more significant risk of tibial cracks ($p = 0.019$).

The IKS score at last follow-up was 88.2 (43–100) and the function score was 72.8 (0–100). No statistically significant

**Figure 1** Location of intraroperative fractures and cracks. ATT: anterior tibial elevation.

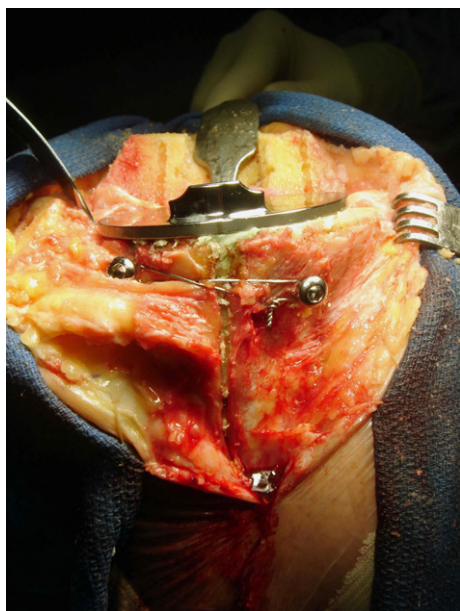


Figure 2 Fixation of tibial cracks with two screws and an eight-shaped metallic wire.

difference was evident in comparison to the series without complications ($p = \text{NS}$).

Two postoperative complications were encountered in follow-up, necessitating a new surgical procedure, with no relationship to the tibial fissure: an ATT fracture occurred three months after arthroplasty (lateral approach with ATT elevation), mandating new osteosynthesis, and femorotibial instability requiring a change of the polyethylene insert 23 months after arthroplasty.

Multifragmented tibial fracture ($n = 1$)

A single epiphyso-metaphysodiaphyseal tibial fracture occurred during knee hyperflexion for tibial preparation after ATT elevation. This fracture was treated by insertion of a long tibial keel in association with internal plate osteosynthesis. Several iterative procedures were necessary for the patient during follow-up: curing the non union and bone autografting associated with new fixation by locked screws, subsequent infection requiring prosthesis ablation, then reimplantation of a posterostabilized prosthesis with a long tibial keel and coated with hydroxyapatite (customized). A satisfactory result was not yet attained at six-month follow-up after the last procedure.

Femoral fissures ($n = 10$)

Fissures of the distal femur ($n = 9$) occurred during impaction of the femoral implant. They were all minimal (without consequent displacement) and did not require fixation or the insertion of femoral keels.

In these cases, full weight bearing was merely delayed by one to two months and knee flexion was limited to 95° during this period.

Perforation of the anterior cortical femur was observed during catheterization of the femoral shaft with an auger of 10 mm diameter. This anterior cortical effraction was limited and was sufficiently far from the knee to warrant any particular precaution.

The IKS score at last follow-up was 89.1 (60–100) and the function score was 75.6 (40–100). There was no statistically significant difference in comparison to the series without complications ($p = \text{NS}$).

ATT fractures ($n = 2$)

These occurred during screw fixation after elevation. New synthesis was then undertaken with screws reinforced by metallic wires. The results were unchanged in comparison to classical ATT elevation (complete stance conditional upon a removable extension splint for 45 days and flexion limited to 95° during this period). There were no postoperative complications.

Tendon and ligament tears

Sectioning of the popliteal tendon ($n = 11$)

The popliteal tendon was cut 11 times by the oscillating saw during posterior femoral sectioning (Fig. 3). In these cases, at the end of surgery, the existent moderate laxity in internal rotating varus flexion was accepted.

No particular precaution was taken in postoperative care. Only a single check-up for the absence of decoaptation on frontal radiographic film in assisted stance (but allowing equilibrium) was performed in the immediate postoperative period.

At last follow-up, the IKS score was 93.67 (90–100) and the function score was 80 (70–100). There were no statistically significant differences in comparison to the patient series without complications ($p = \text{NS}$).

No complications were noted at last follow-up.

Tears of the medial collateral ligament ($n = 10$)

The medial collateral ligament was weakened (but not completely sectioned) by the oscillating saw nine times during tibial cutting, and necessitated reinforcement with absorbable suture in only five cases.

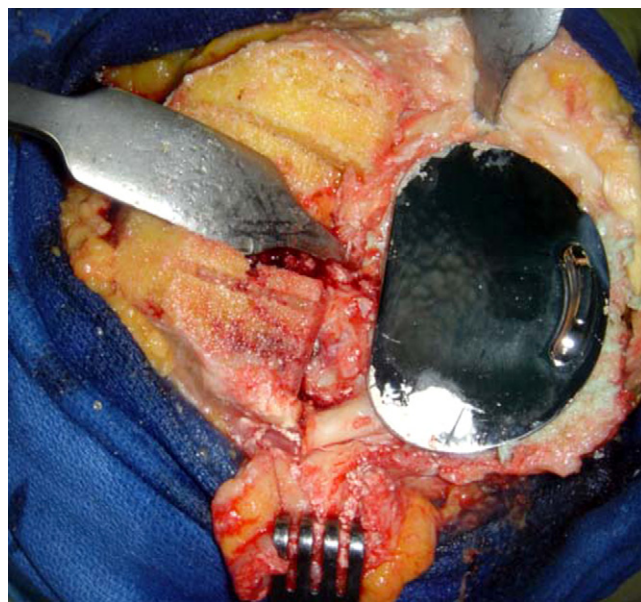


Figure 3 Intraoperative sectioning of the popliteal muscle tendon.

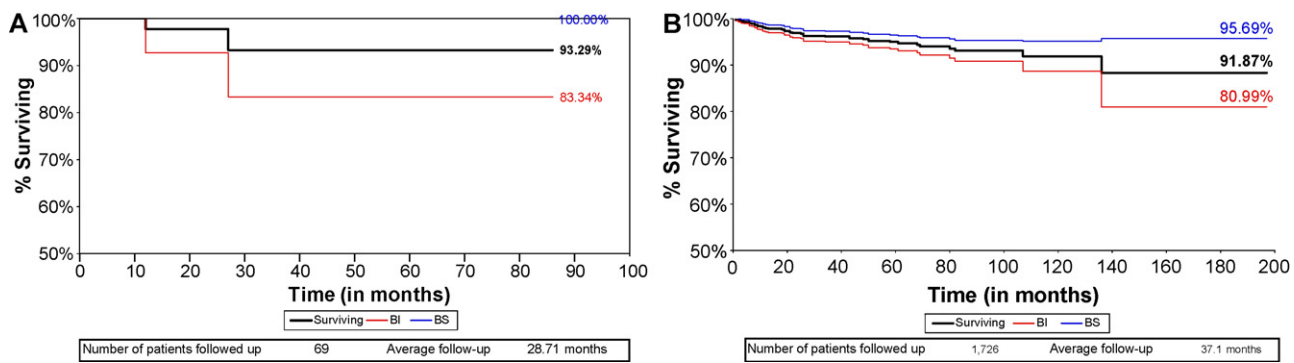


Figure 4 A. Kaplan-Meier survival curve in series with intraoperative complications. Failure: replacement of one or many implant elements (whatever they are). B. Kaplan-Meier survival curve in series without intraoperative complications. Failure: replacement of one or many implant elements (whatever they are).

Incomplete avulsion during anterior tibial luxation required bone reinsertion with anchors. At the end of surgery, there was no abnormal medial laxity during valgus positioning (tested prudently).

As a precaution, all patients were immobilized with an extension splint when walking for two months postoperatively with flexion limited to 95°.

At last follow-up, no patients presented disabling femorotibial instability, and there was also no medial gap on radiographic pictures of the knee in monopodal stance.

At last follow-up, the IKS score was 91.8 (81–100) and the function score was 87.8 (65–100). No statistically significant difference was apparent in comparison to the series without complications ($p = \text{NS}$).

Weakness of the patellar tendon ($n = 6$)

The patellar tendon was weakened six times by the oscillating saw during tibial cutting (without complete sectioning), necessitating a few stitches to repair the cut tendon fibres.

In the postoperative period, simple flexion was limited to 95° for 45 days.

At last follow-up, there was no extensor system deficit in these patients.

The IKS score was 90.5 (70–100) and the function score was 78.4 (40–100).

No other complication occurred subsequently.

Weakness of the quadriceps tendon ($n = 1$)

A single weakness of the quadriceps tendon was caused by the blade during medial parapatellar arthrotomy, with incision of the quadriceps tendon extending towards its lateral portion, not vertical enough, and necessitating simple correction by X type stitches during closure.

No particular precaution was required subsequently, and no complication arose during follow-up.

Implant survival curves

The survival curve of the series of patients with intraoperative complications showed that all prosthetic components were still present in 93.3% of cases at seven and a half years (Fig. 4A). For the series of patients without intraoperative complications, all prosthetic components were still in place

in 93.8% of cases at seven and a half years, and in 91.9% at 16 years (Fig. 4B).

Discussion

The incidence of peroperative complications is rarely reported in the literature.

Fissures and fractures around the knee

Risk factors have been studied [5]. Femoral condyle fractures may occur during femoral implant impaction, especially with a significant posterostabilization cage. There were only 10 cases in our series owing to a posterostabilization cage that was not voluminous because of the third median condyle. It specifically produced cracks, but only on one femoral condyle. To us, it is thus also preferable to drill the entry point of the femoral tunnel with an auger rather than use gouging scissors on a breaking bone.

Diaphyseal femoral fractures during catheterization of the femoral shaft with the centromedullary guide were a classic complication. Fortunately, in our series, we observed only a simple anterior cortical femoral weakness away from the knee which did not necessitate any particular precaution in follow-up, and did not impact the functional prognosis of the TKA. Nevertheless, this type of intraoperative complication may be prevented by the use of centromedullary femoral guides of different diameters and/or lengths, in patients with a small frame, especially if there is significant osteoporosis.

Tibial plateau fractures are rarely displaced and most often are just cracks. They occur during the impaction of implant trays. In our series, this type of complication was favoured by ATT elevation (27 out of 1795 cases, that is 1.5%, and 12 out of 137 ATT elevations, that is, 8.7%, $p < 0.05$).

On the other hand, it appears that the risk of tibial cracks is greater with certain tibial base plate sizes that we are using. In fact, according to the six sizes that we have, the tibial keel has the same dimensions for base plate sizes 1 and 2. For the following sizes, the keel is larger, but the dimensions are constant for plate sizes 3, 4, 5 and 6. Also, it appears that, proportionally, the tibial keel for base plate

size 1 is too large for the tibia of patients with a small frame. This may be prevented by a change in dimensions of the implant keels.

In addition, the use of bone-holding forceps may reduce the risk of tibial fissure, particularly in frontal tibial luxation or during impaction of the tibial base, in small size patients for whom ATT elevation is necessary.

Complex fractures are rare (one case in our series), their treatment is difficult, and they may lead to numerous rein-terventions with the risk of infection.

The prevention of intraoperative fractures and fissures may thus be improved by prosthetic component design (a less voluminous posterostabilization cage and tibial keel are possible), but also by the precautions to be taken during tibial preparation when ATT elevation is required.

Tendon and ligament tears

Gandhi et al. [6] reported three cases of patellar tendon avulsion out of 45 TKA (6.7%), always on straight knees, because of difficult surgical exposure [7,8]. This complication can be prevented by placing a small nail at the supero-medial pole of the ATT, at the insertion point of the most medial fibres of the tendon, before exersion of the patella [13]. Otherwise, ATT elevation may be needed. In our series, only six cases of weaknesses without complete sectioning were noted. These weaknesses occurred during cutting of the tibial plateau with an oscillating saw. They did not subsequently lead to rupture of the extensor system, if precaution was taken to limit flexion postoperatively. In fact, Barrack et al. [14], in 14 cases of secondary extensor system ruptures, did not observe any weaknesses in the course of surgery.

We reported 10 cases of medial collateral ligament tears, each with incomplete sectioning, that occurred during cutting of the tibial plateau, and once during anterior tibial dislocation (incomplete ligament avulsion). A splint when walking during two months postoperatively and the limitation of flexion to 90° during this period prevent subsequent femorotibial instability.

As well, popliteal tendon tears during posterior femoral cutting do not seem to have consequences later on, but it is difficult to evaluate femorotibial instability (laxity in varus flexion and internal rotation provoked by popliteal tendon insufficiency) in flexion at clinical and radiographic examination. Besides, what is true for a normal knee, that is, instability due to popliteal tendon sectioning, may not be as compromising for the prosthetic knee. These complications are not reported in the literature.

The incidence of such peroperative complications and their analysis nevertheless allow us to foresee their prevention: by paying particular attention to tendon avulsions during anterior tibial luxation, protecting these structures with curved knee retractors during tibial cutting, and using less aggressive oscillating saws (not only because of their edge but also because of their lateral deflection), for example.

Finally, we must underscore the fact that all these intraoperative complications can be avoided with surgical experience and good knowledge of the ancillary materials for TKA. In our series, in a university hospital service, numerous procedures are performed by less experienced

or junior operators, under the assistance of senior surgeons. Also, small technical errors may lead to severe complications. For example, in the case of epiphyso-metaphysodiaphyseal fracture of the tibia, the initial technical error that conditions complications is definitely osteotomy of the ATT which extends too far downwards, starting a diaphyseal split.

Implant survival curves

Survival curves for the series of patients with intraoperative complications showed that all prosthetic components were still present in 93.3% of cases at seven and a half years. In the series of patients without intraoperative complications, this survival curve revealed that all prosthetic components were still in place in 93.8% of cases at seven and a half years, and in 91.9% at 16 years.

Thus, in our series, the occurrence of a peroperative fracture or ligament tear did not modify the survival curve of implants at seven and a half-year follow-up and make us hope for a survival curve of nearly 92% at 16-year follow-up.

Conclusion

This large homogeneous series of primary, posterostabilized TKA showed an intraoperative complication rate of 3.8%. All these complications could have been prevented by a strict surgical technique. The improvement of ancillary material, the saws, and good knowledge of the complications by the surgeon are primordial.

Survival curves showed that all prosthetic components were still present in more than 93% of cases at seven and a half-year follow-up, whether they had a peroperative complication or not.

Acknowledgments

The authors thank S. Dojcinovic, C. Bussière and L. Jacquot.

References

- [1] Mulhall KJ, Ghomrawi HM, Scully S, Callaghan JJ, Saleh KJ. Current etiologies and modes of failure in total knee arthroplasty revision. *Clin Orthop* 2006;446:45–50.
- [2] Eisenhuth SA, Saleh KJ, Cui Q, Clark CR, Brown TE. Patellofemoral instability after total knee arthroplasty. *Clin Orthop* 2006;446:149–60.
- [3] Knight JL, Gorai PA, Atwater RD, Grothaus L. Tibial polyethylene failure after primary porous-coated anatomic total knee arthroplasty. *Aids to diagnosis and revision. J Arthroplasty* 1995;10:748–57.
- [4] Ng TP, Chiu KY. Recurrent dislocation of total knee arthroplasty: an unusual cause. *J Arthroplasty* 2003;18:1067–70.
- [5] Kim KI, Egol KA, Hozack WJ, Parvizi J. Periprosthetic fractures after total knee arthroplasties. *Clin Orthop* 2006;446:167–75.
- [6] Gandhi R, De Beer J, Leone J, Petrucci D, Winemaker M, Adili A. Predictive risk factors for stiff knees in total knee arthroplasty. *J Arthroplasty* 2006;21:46–52.
- [7] Rand JA, Morrey BF, Bryan RS. Patellar tendon rupture after total knee arthroplasty. *Clin Orthop* 1989;244:233–8.
- [8] Schoderbek Jr RJ, Brown TE, Mulhall KJ, Mounasamy V, Iorio R, Krackow KA, et al. Extensor mechanism

- disruption after total knee arthroplasty. *Clin Orthop* 2006;446:176–85.
- [9] Asp JP, Rand JA. Peroneal nerve palsy after total knee arthroplasty. *Clin Orthop* 1990;261:233–7.
- [10] Nercessian OA, Ugwonalu OF, Park S. Peroneal nerve palsy after total knee arthroplasty. *J Arthroplasty* 2005;20:1068–73.
- [11] Schinsky MF, Macaulay W, Parks ML, Kieman H, Nercessian OA. Nerve injury after primary total knee arthroplasty. *J Arthroplasty* 2001;16:1048–54.
- [12] Calligaro KD, Dougherty MJ, Ryan S, Booth RE. Acute arterial complications associated with total hip and knee arthroplasty. *J Vasc Surg* 2003;38:1170–7. Erratum in: *J Vasc Surg* 2004;39:628.
- [13] Kelly MA, Clarke HD. Stiffness and ankylosis in primary total knee arthroplasty. *Clin Orthop* 2003;416:68–73.
- [14] Barrack RL, Stanley T, Allen Butler R. Treating extensor mechanism disruption after total knee arthroplasty. *Clin Orthop* 2003;416:98–104.